Biological Assessment Report

Old Mines Creek
Washington County, Missouri

2011 - 2012

Prepared for:

Missouri Department of Natural Resources
Division of Environmental Quality
Water Protection Program
Water Pollution Control Branch

Prepared by:

Missouri Department of Natural Resources
Division of Environmental Quality
Environmental Services Program
Water Quality Monitoring Section

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1.0 Introduction

At the request of the Missouri Department of Natural Resources (**MDNR**) Water Protection Program (**WPP**), the Environmental Services Program (**ESP**) Water Quality Monitoring Section (**WQMS**) conducted a biological assessment of Old Mines Creek. Old Mines Creek is located in the Ozark/Meramec Ecological Drainage Unit (**EDU**), originating in east central Washington County, Missouri. Old Mines Creek is designated as a Class C stream (Water Body Identification [**WBID**] 2112) in the Missouri Water Quality Standards (MDNR 2012a) for one mile starting approximately four miles north of Potosi in Washington County, to 0.1 miles downstream of Washington County Road 361. The rest of Old Mines Creek is designated as a Class P stream (WBID 2111) for 6.6 miles to its confluence with Mineral Fork. Designated uses for Old Mines Creek are "warm water aquatic life protection, human health/fish consumption, and livestock and wildlife watering" (MDNR 2012a). Additionally, the Class P portion of Old Mines Creek has a designated use of class A whole body contact recreation, while the Class C portion has a designated use of class B whole body contact recreation.

1.1 Study Area/Justification

Barite strip mining began in the early 1970s in the Big River drainage. This drainage contains the Old Mines Creek watershed. The majority of the mining took place east of Missouri State Highway 185 and by 1978 over 20,000 acres were affected (MDC 1997; USDA 1980). Most mining has ceased, but many mine tailings ponds, dams, and waste piles remain (MDC 1997).

1.2 Objectives

1) Assess the biological (macroinvertebrate) integrity and water quality of the Old Mines Creek watershed.
2) Determine stream habitat quality of Old Mines Creek.
3) Characterize the fine sediment of Old Mines Creek.

1.3 Tasks

1) Conduct a biological assessment on Old Mines Creek.
2) Conduct a stream habitat assessment at the sampling stations to ensure comparability of aquatic habitats.
3) Collect water samples, fine sediment samples, and water quality field measurements at the bioassessment sampling stations.

1.4 Null Hypotheses

1) The macroinvertebrate community will not differ between longitudinally separate reaches of Old Mines Creek.
2) The macroinvertebrate community in Old Mines Creek will not differ from the riffle/pool biological criteria for the Ozark/Meramec EDU.
3) The stream habitat assessment scores will not differ between longitudinally separate reaches of Old Mines Creek.

4) The stream habitat assessment scores in Old Mines Creek will not differ from Brazil Creek, a candidate riffle/pool biological criteria reference stream in the Ozark/Meramec EDU.
5) Physicochemical water quality will not differ between longitudinally separate reaches of Old Mines Creek.
6) Physicochemical water quality in Old Mines Creek will meet the Water Quality Standards of Missouri (MDNR 2012a).
7) Total metals in the fine sediment will not differ between longitudinally separate reaches of Old Mines Creek.
8) Total metals in the fine sediment of Old Mines Creek will not exceed consensus-based guidelines.

2.0 Methods

Mike Irwin of the Biological Assessment Unit, WQMS, ESP, Division of Environmental Quality (**DEQ)**, MDNR, conducted this study. Bioassessment and physicochemical field work for the fall 2011 and spring 2012 sampling seasons was conducted by Mike Irwin, Sam McCord, and Dave Michaelson of the Biological Assessment Unit. Fine sediment characterization field work was conducted by Mike Irwin and Brandy Bergthold of the Biological Assessment Unit on November 5, 2012.

2.1 Study Timing

Macroinvertebrate and discrete water quality samples were collected at each sampling station once during the fall 2011 and spring 2012 sampling seasons. Habitat assessments for all Old Mines Creek stations were completed during the fall 2011 season. Fine sediment sampling was conducted on November 5, 2012.

2.2 Station Descriptions

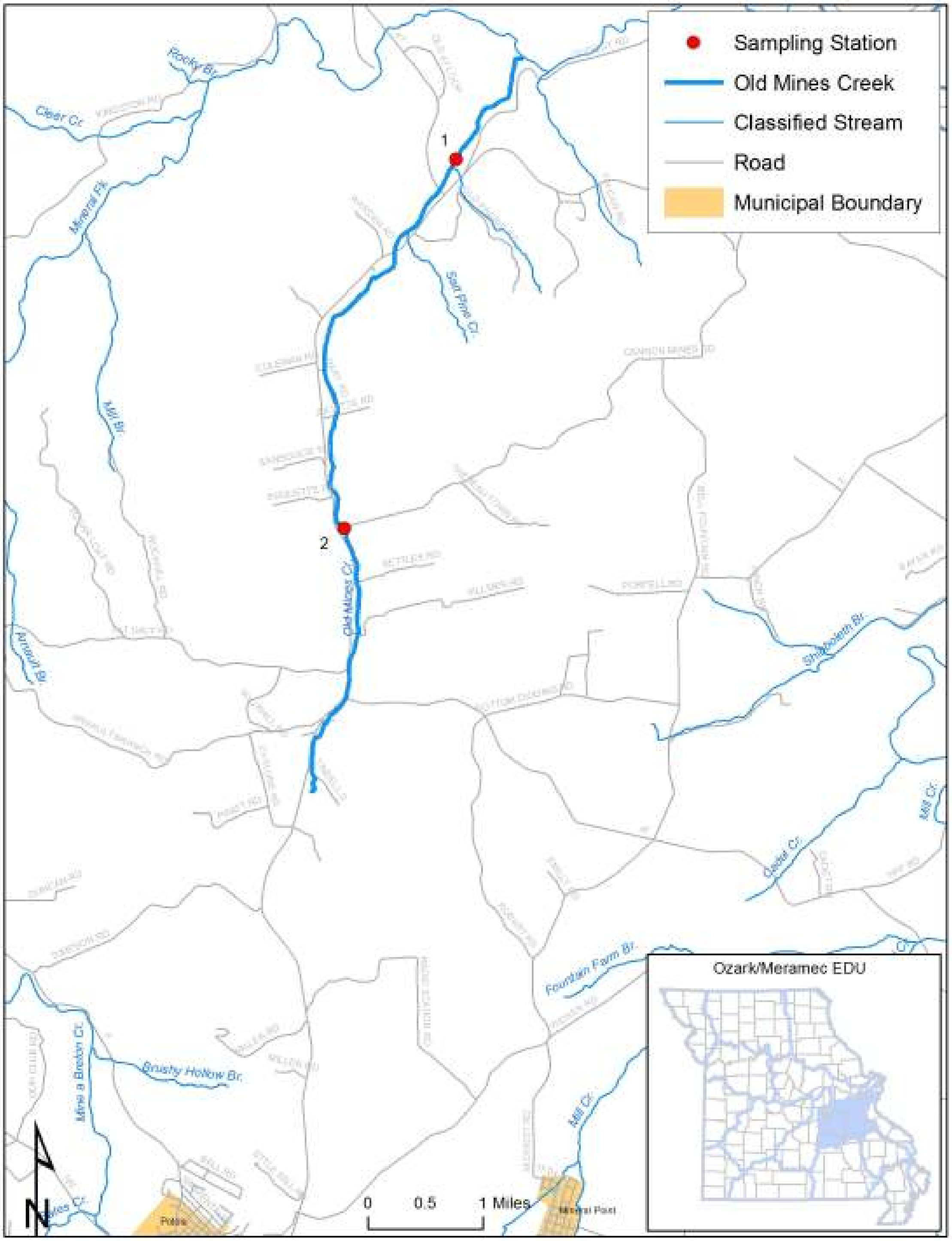
The study area and sampling locations for the Old Mines Creek bioassessment study are shown in Figure 1. Two Old Mines Creek stations were surveyed for bioassessment sampling, water quality, and fine sediment characterization.

2.2.1 Bioassessment Sampling Stations

Old Mines Creek #1 – Washington County: Legal description was SE¼ NE¼ Sec. 30, T39N, R3E. Geographic coordinates were UTM zone 15, 0698509 Easting, 4217051 Northing. The station was located downstream of Washington County Road 317.

Old Mines Creek #2 – Washington County: Legal description was Survey 3039, T38N, R2E. Geographic coordinates were UTM zone 15, 0696941 Easting, 4211875 Northing. The station was located downstream of Cannon Mines Road.

Figure 1
Map of Old Mines Creek and Sampling Stations



2.3 Ecological Classification

The Old Mines Creek watershed is located in the Ozark Highlands ecoregion. The aquatic ecological classification developed by the Missouri Resource Assessment Partnership (**MoRAP**) is a classification system that divides the aquatic resources of Missouri into distinct regions. It has seven levels of classification starting at large regions and then dividing them into smaller sub-regions (Sowa & Diamond 2006). The following are the seven levels of classification in hierarchical order: zone, subzone, region, aquatic subregions, EDU, Aquatic Ecological Systems (**AES**), and Valley Segment Types (**VST**). The levels of classification are based on biology, zoogeography, taxonomic composition, geology, soils, and groundwater connection. Some levels of the hierarchical system use geology and soils to classify and other levels use biology and taxonomic composition of aquatic communities. EDU and AES are the two levels of the classification system that will be assessed in detail for this study.

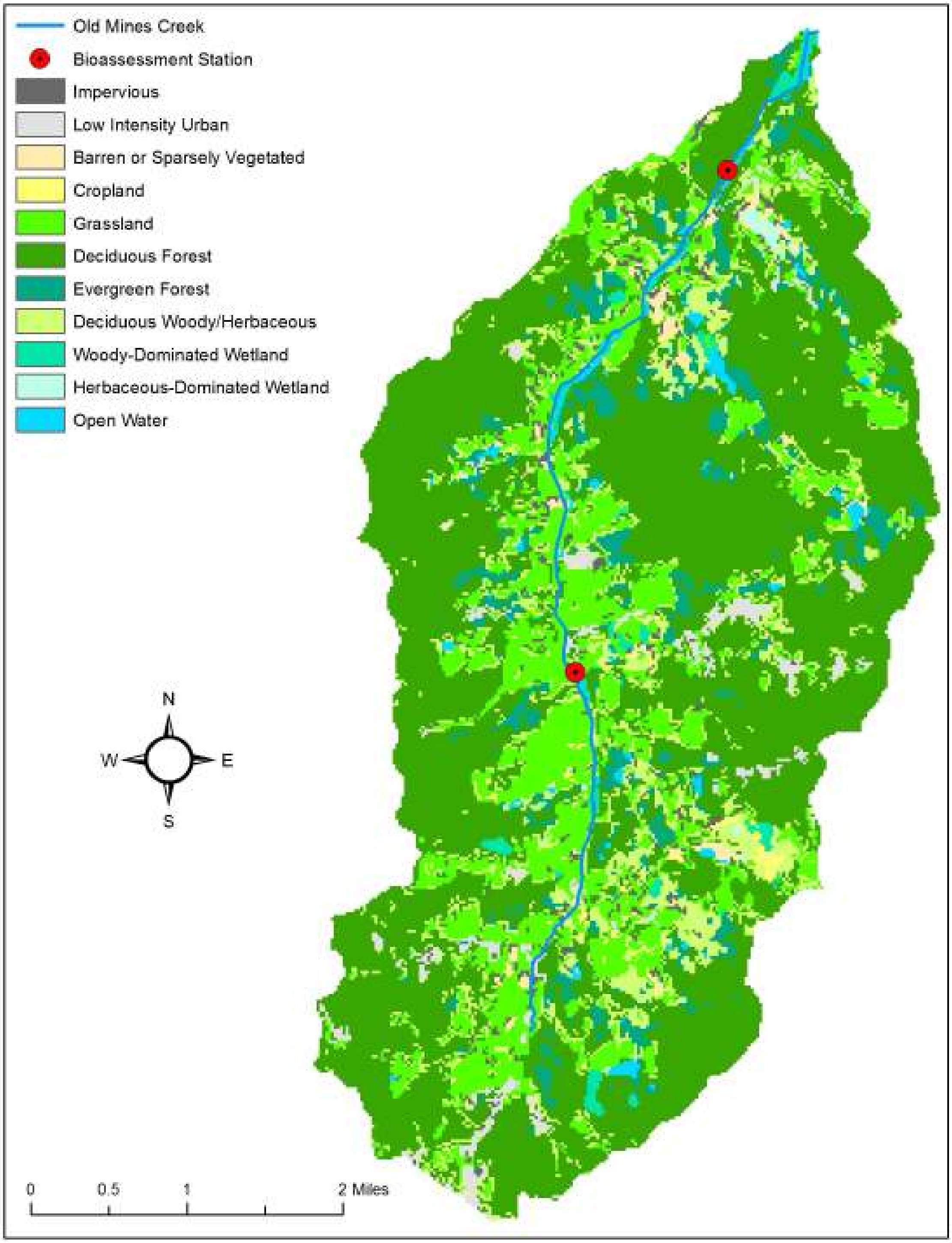
2.3.1 Ecological Drainage Unit

The EDU is level five of the classification hierarchy and is based on geographical variation of the taxonomic composition of the level four subregions. An EDU is a region in which aquatic biological communities and habitat conditions can be expected to be similar. Table 1 shows the land cover percentages from the Ozark/Meramec EDU and the 12-digit hydrologic unit codes (**HUC**) that contain watersheds of the Old Mines Creek sampling stations. Land use conditions were summarized from land cover geographic information system (**GIS**) files. Percent land cover data were derived from Thematic Mapper satellite data collected between 2000 and 2004 and interpreted by the MoRAP (Sowa et al. 2004). Figure 2 is a map of the land cover within the 12-digit HUCs associated with the Old Mines Creek study reach. Old Mines Creek land cover is more similar to the Ozark/Meramec EDU than it is to biological reference streams and the candidate biological reference stream.

Table 1
Percent Land Use/Land Cover

HUC12/EDU	Impervious	High Intensity Urban	Low Intensity Urban	Barren or Sparsely Vegetated	Cropland	Grassland	Deciduous Forest	Evergreen Forest	Deciduous Woody/Herbaceous	Woody-Dominated Wetland	Herbaceous-Dominated Wetland	Open Water
Old Mines Creek (071401040205)	1.6	0	2.3	0.8	0.8	17.3	58.2	6.0	10.6	1.1	0.2	1.1
Ozark/Meramec EDU	1.5	0.1	2.9	0.5	1.9	27.8	54.5	2.7	5.6	0.8	0.1	1.4
Huzzah Creek (071401020403)	0.6	0.1	0.1	0.3	0.4	20.4	71.5	0.8	5.3	0.1	0	0.4
Meramec River (071401020207)	0.5	0	0	0.3	0.5	16.8	75.2	0.4	4.2	0.1	0.7	1.2
Brazil Creek (071401020701)	0.4	0	0.5	0.2	0.3	15.1	77.7	1.2	4.0	0	0	0.7

Figure 2
Map of Old Mines Creek Land Use/Land Cover



2.3.2 Aquatic Ecological Systems

AES are level six of the classification hierarchy and classify aquatic systems into types based on geology, soils, landform, and groundwater influence. Old Mines Creek is located in the Indian Creek Aquatic Ecological Systems Type. According to Sowa and Diamond (2006):

> This AES-Type is scattered in small patches throughout the eastern Ozarks. Local relief ranges from 15 to nearly 90 meters. Surface soil textures are cherty and exhibit moderate infiltration rates. These soils are underlain by dolomite or occasionally sandstone. Springs are relatively common with 65 headwater/creek springs and seven main stem springs scattered throughout the Missouri portion of this AES-Type. The median spring count is 9. The combined headwater and creek mean stream gradient is 14.6 meters per kilometer.

2.4 Stream Habitat Assessment

A standardized assessment procedure was followed as described for riffle/pool habitat in the Stream Habitat Assessment Project Procedure (**SHAPP**) (MDNR 2012b). Habitat assessments were conducted on Old Mines Creek stations during September of 2011 and Brazil Creek in October 2011. Brazil Creek, a candidate biological reference stream (**BIOREF**), was chosen for habitat comparison because it is more similar in size to Old Mines Creek than the Meramec River or Huzzah Creek biological reference stream reaches.

2.5 Biological Assessment

Biological assessments consist of macroinvertebrate collection and physicochemical sampling for two sample periods.

2.5.1 Macroinvertebrate Collection and Analysis

A standardized macroinvertebrate sample collection and analysis procedure was followed as described in the Semi-quantitative Macroinvertebrate Stream Bioassessment Project Procedure (**SMSBPP**) (MDNR 2010a) for riffle/pool (**RP**) streams. Samples were collected from the following standard RP habitats: coarse substrate (**CS**); depositional substrate in non-flowing water (**NF**); and root mat (**RM**).

Macroinvertebrate data were analyzed using three methods. The first analysis was calculating the Macroinvertebrate Stream Condition Index (**MSCI**). The MSCI is calculated using the biological criteria for perennial/wadeable streams from the Ozark/Meramec EDU using the four general biological metrics found in the SMSBPP (MDNR 2010a). The four general biological metrics used and found in the SMSBPP are: 1) Taxa Richness (**TR**); 2) Ephemeroptera/Plecoptera/Trichoptera Taxa (**EPTT**); 3) Biotic Index (**BI**); and 4) Shannon Diversity Index (**SDI**). The second analysis was an evaluation of macroinvertebrate community composition by percent composition of dominant macroinvertebrate groups. Comparisons of the macroinvertebrate community between the Old Mines Creek stations were made. The third analysis was an evaluation of the predominance of taxa of varying BI ranges at each station and collectively for

biological reference streams within the Ozark/Meramec EDU. Taxa were divided into the following five BI tolerance value ranges in order of most sensitive to most tolerant: 0 to <2.5, 2.5 to 4.9, 5.0 to 7.4, 7.4 to 9.0, and >9.0. Percentages of total taxa were then calculated for each of these five sensitivity/tolerance ranges.

2.6 Physicochemical Data Collection and Analysis

2.6.1 *In situ* Water Quality Measurements

During each sampling period, *in situ* water quality measurements were collected at all of the bioassessment stations. Field measurements included turbidity (**NTU**), pH (**su**), water temperature (**°C**), specific conductance (**µS/cm**), and dissolved oxygen (**mg/L**). For these measurements, the following Standard Operating Procedures (**SOP**) were used: turbidity, MDNR-ESP-012 (MDNR 2010b); pH, MDNR-ESP-100 (MDNR 2012c); water temperature, MDNR-ESP-101 (MDNR 2012d); specific conductance, MDNR-ESP-102 (MDNR 2010c); dissolved oxygen, MDNR-ESP-103 (MDNR 2012e).

2.6.2 Water Chemistry

Grab samples of stream water were collected and returned for analyses to ESP's Chemical Analysis Section (**CAS**). Samples from the bioassessment sampling and water quality stations were analyzed for non-filterable residue (**NFR**), chloride (**Cl**), total phosphorus (**TP**), ammonia-N (**NH_3N**), nitrate+nitrite-N (**NO_3+NO_2-N**), total nitrogen (**TN**), hardness, and dissolved metals. Procedures outlined in Field Sheet and Chain-of-Custody Record (MDNR 2010d) and Required/Recommended Containers, Volumes, Preservatives, Holding Times, and Special Sampling Considerations (MDNR 2011) were followed when collecting water quality samples. NFR, Cl, TP, NH_3-N, NO_3+NO_2-N, TN, and hardness are reported in mg/L. For dissolved metals, magnesium (**Mg**) and Calcium (**Ca**) are reported in mg/L, while barium (**Ba**), cadmium (**Cd**), cobalt (**Co**), copper (**Cu**), lead (**Pb**), nickel (**Ni**) and zinc (**Zn**) are reported in µg/L.

Stream velocity was measured at each station during the survey period using a Marsh-McBirney Flo-Mate™ Model 2000. Discharge was calculated per the methods in the SOP MDNR-ESP-113, Flow Measurement in Open Channels (MDNR 2010e). Discharge is reported as cubic feet per second (**cfs**).

2.6.3 Fine Sediment Character

Fine sediment was characterized at each sampling station for Cd, Pb, and Zn. Each sample was a composite of one 2-ounce jar collected downstream of three separate riffles, yielding an approximate 6-ounce total composite. These composites were then dried and analyzed by CAS for total cadmium, lead, and zinc. Procedures outlined in Field Sheet and Chain-of-Custody Record, SOP MDNR-ESP-002 (MDNR 2010d), and Required/Recommended Containers, Volumes, Preservatives, Holding Times, and Special Sampling Considerations, SOP MDNR-ESP-001 (MDNR 2011), were followed when collecting fine sediment samples. Results are reported in mg/kg.

2.7 Data Analysis and Quality Control

The physicochemical data were examined by variable to identify stations that had violations of the Missouri Water Quality Standards (MDNR 2012a). Sampling stations with values that were higher or lower than the water quality standards will be discussed with possible influences being identified. Values for total metals in fine sediment were measured against the consensus-based Probable Effects Concentration (**PEC**) for these metals (McDonald et al. 2000). The PEC is the level of a contaminant above which harmful effects are likely to be observed. The dry-weight PECs for cadmium, lead, and zinc are 4.98 mg/kg, 128 mg/kg, and 459 mg/kg, respectively.

3.0 Results

3.1 Stream Habitat Assessment

Habitat assessment scores for the Old Mines Creek stations and the Brazil Creek candidate biological reference reach are shown in Table 2. Data were collected in September and October 2011 with Mike Irwin and Dave Michaelson performing the scoring. SHAPP guidance states that stations scoring at least 75 percent of the total score of reference/control stations should support a similar biological community. The stream habitat total scores indicated that both Old Mines Creek stations should support a similar macroinvertebrate community compared to the Brazil Creek candidate biological reference stream reach. Habitat parameter categories range from I (optimal) to IV (poor). Habitat parameter scores are listed in parentheses and range from 0 to 20 except for vegetative protection and riparian zone categories, which range from 0 to 10.

Table 2
Predominant Category Habitat Values, Category Habitat Scores, and Total Habitat Scores from Stream Habitat Assessments for the Old Mines Creek Stations and the Brazil Creek Candidate Biological Reference Stream Reach

Stream Habitat Parameters	Old Mines Cr #1	Old Mines Cr #2	Brazil Cr #1
SHAPP Date	9/22/2011	9/22/2011	10/4/2011
Epifaunal Substrate/Available Cover	IV (4)	I (19)	I (17)
Embeddedness	I (19)	I (17)	I (16)
Velocity/Depth Regime	III (6)	II (14)	II (15)
Sediment Deposition	II (15)	II (15)	II (13)
Channel Flow Status	II (15)	II (15)	III (10)
Channel Alteration	I (20)	I (19)	I (20)
Riffle Quality	IV (2)	I (20)	II (13)
Bank Stability – Left Bank	I (10)	I (10)	I (9)
Bank Stability – Right Bank	I (10)	I (9)	I (10)
Vegetative Protection – Left Bank	I (9)	I (9)	II (7)
Vegetative Protection – Right Bank	II (7)	II (6)	IV (2)
Riparian Zone Width – Left Bank	I (10)	III (5)	I (10)
Riparian Zone Width – Right Bank	I (10)	I (9)	I (10)
Total Habitat Score (% of BIOREF)	**137 (90)**	**167 (110)**	**152 (100)**

3.2 Macroinvertebrate Biological Assessment

3.2.1 Semi-quantitative Macroinvertebrate Stream Bioassessment Project Procedure (SMSBPP)

MSCI scores were calculated at the Old Mines Creek stations using the riffle/pool perennial/wadeable biological criteria for the Ozark/Meramec EDU. The MSCI scores for the fall 2011 and spring 2012 sampling seasons are shown in Table 3. Values shown in bold type are metric scores that are below the fully biologically supporting criteria.

Table 3
Fall 2011 and Spring 2012 Riffle/Pool Ozark/Meramec EDU Perennial/Wadeable Biological Criteria, Macroinvertebrate Stream Condition Index (MSCI) Scores, and Sustainability Categories at Old Mines Creek Stations

Station	TR (Score)	EPTT (Score)	BI (Score)	SDI (Score)	Total Score	Sustainability
Fall 2011						
Old Mines Cr #1	100 (5)	26 (5)	**6.2 (3)**	3.31 (5)	18	Fully Biologically Supporting
Old Mines Cr #2	95 (5)	25 (5)	5.4 (5)	3.61 (5)	20	Fully Biologically Supporting
Score of 5	>79	>21	<5.8	>3.09	--	Fully Biologically Supporting
Score of 3	79 - 39	21 - 11	5.8 - 7.9	3.09 - 1.55	--	Partially Biologically Supporting
Score of 1	<39	<11	>7.9	<1.55	--	Non-Biologically Supporting
Spring 2012						
Old Mines Cr #1	107 (5)	**23 (3)**	**6.5 (3)**	3.48 (5)	16	Fully Biologically Supporting
Old Mines Cr #2	100 (5)	**26 (3)**	5.3 (5)	3.67 (5)	18	Fully Biologically Supporting
Score of 5	>92	>29	<5.8	>3.33	--	Fully Biologically Supporting
Score of 3	92 - 46	29 - 15	5.8 - 7.9	3.33 - 1.67	--	Partially Biologically Supporting
Score of 1	<46	<15	>7.9	<1.67	--	Non-Biologically Supporting

In the fall 2011 sampling season, MSCI scores placed both stations in the fully biologically supporting category. Station #1 received a score of 18 due to a BI value that was higher than the fully biologically supporting criterion, while Station #2 received a score of 20. In the spring 2012 sampling season, MSCI scores again placed both stations in the fully biologically supporting category. Station #1 received a score of 16 due to an EPTT value below the fully biologically supporting criterion and a BI value that was higher than the fully supporting biological criterion. Station #2 received a score of 18 due to an EPTT value below the fully biologically supporting criterion.

3.2.2 Percent EPTT and Dominant Macroinvertebrate Families

The percent of EPTT and the five dominant macroinvertebrate families at both Old Mines Creek stations are presented in Table 4. Values in bold type represent the five dominant macroinvertebrate families and taxa for each station.

Table 4
Percent EPT & Dominant Macroinvertebrate Families at the Old Mines Creek Stations

Fall 2011	Old Mines Cr #1	Old Mines Cr #2
EPTT Metrics		
% EPT	30.0	40.5
% Ephemeroptera	27.8	28.3
% Plecoptera	2.1	11.1
% Trichoptera	0.1	1.1
Percent Dominant Families (Top 5 for each station in **bold**)		
Chironomidae	**47.2**	**26.3**
Caenidae	**16.3**	**12.2**
Elmidae	**10.3**	**11.5**
Heptigeniidae	**4.9**	3.7
Leptohyphidae	**3.6**	0.0
Hydropsychidae	0.8	**6.0**
Baetidae	1.7	**5.4**
Spring 2012	Old Mines Cr #1	Old Mines Cr #2
EPT Metrics		
% EPT	24.4	36.7
% Ephemeroptera	22.0	21.8
% Plecoptera	2.1	12.2
% Trichoptera	0.3	2.7
Percent Dominant Families (Top 5 for each station in **bold**)		
Chironomidae	**50.7**	**40.1**
Caenidae	**16.2**	**7.8**
Elmidae	**6.3**	**10.0**
Arachnoidea*	**3.3**	1.0
Leptohyphidae	**2.9**	0.0
Heptageniidae	2.1	**8.5**
Hydropsychidae	0.4	**5.5**

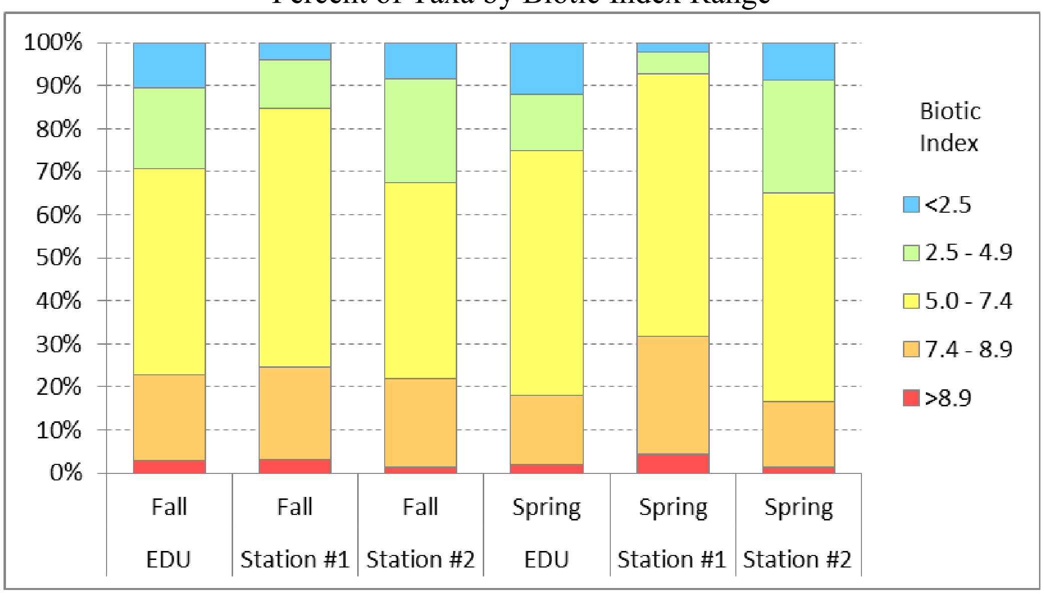
*Identified only to Class

For fall 2011 Old Mines Creek samples, station #2 had the higher percent EPTT of 40.5%, while station #1 had a percent EPTT of 30.0%. For spring 2012 Old Mines Creek samples, station #2 again had the higher percent EPTT at 36.7%, while station #1 had a percent EPTT at 24.4%. Most notable regarding EPTT are much higher percentages of Plecoptera and Trichoptera at station #2 for both seasons. In fall 2011 Old Mines Creek

samples, Chironomidae, Caenidae, and Elmidae were dominant families at both stations. Heptageniidae and Leptohyphidae were dominant at station #1, while Hydropsychidae and Baetidae were dominant at station #2. In spring 2012 Old Mines Creek samples, Chironomidae, Caenidae, and Elmidae were dominant families again at both stations. Arachnoidea and Leptohyphidae were dominant at station #1, while Heptageniidae and Hydropsychidae were dominant at station #2. Most notable was the lack of Leptohyphidae at station #2 for both seasons. The dominance of Hydropsychidae at station #2 for both seasons is notable as well.

Since BI played a primary role in the reduction of MSCI scores, additional detail was generated for this metric. The percent of taxa by BI range is presented in Figure 3. Macroinvertebrate taxa that are sensitive to organic pollution were more common in station #1 than they were in station #2 or the Ozark/Meramec EDU. The general tendency of station #1 is toward more tolerant taxa. Station #2 compared relatively well to the Ozark/Meramec EDU.

Figure 3
Percent of Taxa by Biotic Index Range



3.3 Physicochemical Data

Water samples and field measurements were collected during the fall 2011 and spring 2012 macroinvertebrate sampling periods at Old Mines Creek stations. Results for field measurements and nutrients can be found in Table 5. Results for hardness and dissolved metals can be found in Table 6.

Table 5
Field Measurements and Nutrients at Old Mines Creek Bioassessment Study Sampling Stations

Station	Date/Time	NH_3-N mg/L	Cl mg/L	DO mg/L	pH su	SC µS/cm	Temp °C	NTU mg/L	Flow cfs	NO_3+NO_2-N mg/L	NFR mg/L	TN mg/L	TP mg/L
Old Mines Cr #1	9/22/2011 10:35	<0.03*	4.90**	9.29	8.40	554	16.5	0.70	2.6	0.16	<5*	0.25	<0.01*
Old Mines Cr #2	9/22/2011 13:20	<0.03*	4.31**	8.76	8.50	541	15.2	1.03	2.6	0.32	<5*	0.37	<0.01*
Old Mines Cr #1	3/22/2012 12:15	<0.03*	5.06	11.30	8.50	431	15.9	1.73	13.77	0.12	<5*	0.25	0.018**
Old Mines Cr #2	3/22/2012 13:30	<0.03*	5.09	11.17	8.38	415	15.8	1.28	5.58	0.14	<5*	0.24	0.017**

* Below detectable limits ** Estimated Value

Table 6
Dissolved Metals and Hardness at Old Mines Creek Bioassessment Study Sampling Stations

Station	Date/Time	Ba µg/L	Cd µg/L	Co µg/L	Cu µg/L	Pb µg/L	Ni µg/L	Zn µg/L	Ca mg/L	Mg mg/L	Hardness mg/L
Old Mines Cr #1	9/22/2011 10:35	1120	<0.1*	<1*	0.77**	<0.5*	<0.5*	18.5	61.1	37.5	307
Old Mines Cr #2	9/22/2011 13:20	1040	<0.1*	<1*	1.18	<0.5*	<0.5*	15.4	59.1	39.0	308
Old Mines Cr #1	3/22/2012 12:15	774	<0.1*	<1*	1.01	<0.5*	0.91**	10.0	48.4	29.5	242
Old Mines Cr #2	3/22/2012 13:30	822	<0.1*	<1*	0.88**	<0.5*	0.93**	15.4	46.5	28.3	233

* Below detectable limits ** Estimated Value

In regards to field measurements and nutrients, there were no notable values, and parameters were within the applicable limits of Missouri's Water Quality Standards. Cadmium, cobalt, and lead concentrations were below detection limits, but barium levels appeared to be elevated. Copper and zinc were above detection limits for both seasons, and nickel was above detection limits in spring 2012. None of the dissolved metals values, however, were in violation of Missouri's Water Quality Standards.

Fine sediment samples were collected on November 6, 2012, at Old Mines Creek stations. Total cadmium levels are not above PEC, but two total lead values and one total zinc value were well above PEC. Results for fine sediment characterization can be found in Table 7. Values shown in bold are above PEC.

Table 7
Total Metals Character in Fine Sediment of Old Mines Creek

Station	Cadmium mg/kg	Lead mg/kg	Zinc mg/kg
Old Mines Cr #1	0.90	**171**	388
Old Mines Cr #2	2.86	**203**	**751**
PEC	4.98	128	459

4.0 Discussion

A habitat assessment was not completed for a BIOREF stream in the same EDU; however, the high quality of habitat found in the candidate biological reference stream should be sufficient for habitat assessment comparisons in this study. Stream habitat total scores indicated that both Old Mines Creek stations should support a macroinvertebrate community similar to the reference conditions in the Ozark/Meramec EDU. Considering that MSCI scores are categorized as fully biologically supporting at both stations for both seasons, this appears to be the case. Additionally, physicochemical results yielded no violations of Missouri's Water Quality Standards.

Even though there were notable differences between Old Mines Creek stations in regard to macroinvertebrate assemblages, physicochemical differences are more difficult to discern. Dissolved metals from abandoned mines might have an effect on macroinvertebrate assemblages, but some of these differences are likely due to habitat. Station #1 BI scores were low for both seasons relative to station #2 and the Ozark/Meramec EDU. This is likely due to habitat differences, primarily a lack of epifaunal substrate/available cover. Station #1 was primarily small pockets of gravel on bedrock with limited pools and rootmat. Epifaunal substrate/available cover, velocity/depth regime, and riffle quality ranked lower at station #1 than station #2. While not significant enough to cause a change in biological sustainability status, these conditions likely had an effect on the macroinvertebrate community. Even though the habitat assessment total score was lowest for station #1, however, habitat is still comparable to reference conditions in the Ozark/Meramec EDU.

For station #1, total lead in fine sediment was above PEC. For station #2, total lead and zinc in fine sediment were above PEC. Whether the metals found in the fine sediment of Old Mines Creek are biologically available or not is beyond the scope of this study. Total lead and zinc in fine sediment did not appear to have an effect on macroinvertebrate taxa numbers or diversity. Reductions in EPTT and BI scores resulted in slightly lower MSCI scores. Whether this is due to elevated levels of heavy metals in fine sediment is indeterminable, but it is a distinct possibility.

5.0 Conclusions

The first null hypothesis stated that the macroinvertebrate community will not differ between longitudinally separate reaches of Old Mines Creek. Although habitat is likely a factor, in-depth study of the macroinvertebrate assemblages does show a difference between the stations. Therefore, the first null hypothesis is rejected. The second null hypothesis stated that the macroinvertebrate community in Old Mines Creek will not differ from the riffle/pool biological criteria for the Ozark/Meramec EDU. There are some differences in macroinvertebrate assemblages, but MSCI scores for both stations were fully biologically supporting for both stations and seasons. The second null hypothesis is accepted.

The third null hypothesis stated that the stream habitat assessment scores will not differ between longitudinally separate reaches of Old Mines Creek. While the habitat assessment total score for station #1 was lower than station #2, it is above the 75 percent threshold value and is considered comparable. The fourth null hypothesis stated that the stream habitat assessment scores in Old Mines Creek will not differ from Brazil Creek, a candidate riffle/pool biological criteria reference stream in the Ozark/Meramec EDU. The stream habitat assessment results were well above the 75 percent value of the Brazil Creek candidate biological criteria reference station habitat score. These results led to the acceptance of the third and fourth null hypotheses of this study.

The fifth hypothesis stated that physicochemical water quality will not differ between longitudinally separate reaches of Old Mines Creek. Since there were no obvious differences, the fifth null hypothesis is accepted. The sixth hypothesis stated physicochemical water quality in Old Mines Creek will meet the Water Quality Standards of Missouri (MDNR 2010a). There were no violations of Missouri's Water Quality Standards, so the sixth null hypothesis is accepted.

The seventh null hypothesis stated total metals in the fine sediment will not differ between longitudinally separate reaches of Old Mines Creek. Since station #1 only exceeded the PEC for lead, while station #2 exceeded the PECs for both lead and zinc, this hypothesis is rejected. The eighth hypothesis stated total metals in the fine sediment of Old Mines Creek will not exceed consensus-based guidelines. Since there were exceedances of PECs, this hypothesis is also rejected.

Even though negative effects of abandoned barite mines on aquatic biological communities cannot be completely ruled out due to elevated total lead and zinc in fine sediments, MSCI

scores show Old Mines Creek to be fully biologically supporting, and there are no violations of Missouri's Water Quality Standards.

6.0 Recommendations

- Studies that identify levels of dissolved metals bioaccumulated in taxa should be conducted periodically.

- Studies to determine specific macroinvertebrate/metal sensitivities, if possible, would be very helpful.

- Studies to determine the amount of dissolved metals in pore water within the sediment might provide additional insight.

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Submitted by: ____

Michael D. Irwin
Environmental Specialist
Water Quality Monitoring Section
Environmental Services Program

Date: ____

Approved by: ____

Alan Reinkemeyer
Director
Environmental Services Program

AR:mit

c: Trish Rielly, QAPP Project Manager, WPP
Jackson Bostic, Director, Southeast Regional Office

Appendix A

Old Mines Creek Macroinvertebrate Taxa Lists

(16 pages)

Old Mines Cr [110967], Station #1, Sample Date: 9/22/2011 12:30:00 PM
CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
"HYDRACARINA"			
Acarina	8	2	29
AMPHIPODA			
Hyalella azteca			2
COLEOPTERA			
Berosus			2
Dubiraphia	10	20	62
Ectopria nervosa	5		2
Helichus lithophilus			2
Lutrochus	2		
Macronychus glabratus			4
Microcylloepus pusillus	6		1
Optioservus sandersoni	4		
Psephenus herricki	1		1
Stenelmis	33	8	4
DECAPODA			
Orconectes medius	-99		
Orconectes punctimanus			-99
DIPTERA			
Ablabesmyia	5	7	3
Atherix	-99		
Ceratopogoninae	4	6	5
Chrysops		2	
Cladopelma		1	
Cladotanytarsus	15	24	9
Clinotanypus		2	3
Cricotopus bicinctus	1	1	
Cricotopus/Orthocladius	5	3	4
Cryptochironomus	1	1	1
Cryptotendipes		1	
Dicrotendipes	11	9	
Forcipomyiinae			1
Hemerodromia		1	
Labrundinia		1	8
Microtendipes	6	1	1

Old Mines Cr [110967], Station #1, Sample Date: 9/22/2011 12:30:00 PM
CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
Nanocladius	1	1	
Natarsia		1	
Nilotanypus	2		
Nilothauma	4	5	
Parakiefferiella		3	
Paralauterborniella		2	1
Parametriocnemus	4		
Phaenopsectra	9	6	1
Polypedilum convictum	2		
Polypedilum illinoense grp			5
Polypedilum scalaenum grp	7	3	
Procladius		2	
Pseudochironomus	17	21	10
Simulium	1	1	
Stempellina		1	
Stempellinella	79	38	8
Tabanus	3		
Tanytarsus	87	133	49
Thienemannimyia grp.	13	3	2
Tribelos	7	41	1
EPHEMEROPTERA			
Acentrella	1		
Apobaetis		1	
Baetis	13		1
Caenis anceps	14	7	23
Caenis latipennis	109	84	3
Choroterpes	4		
Eurylophella	1		1
Hexagenia limbata		-99	
Isonychia bicolor	9		
Leptophlebiidae			3
Maccaffertium mediopunctatum	29		
Maccaffertium pulchellum	28		
Procloeon	3	3	4
Stenacron	12	1	
Stenonema femoratum	1	1	

Old Mines Cr [110967], Station #1, Sample Date: 9/22/2011 12:30:00 PM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	**CS**	**NF**	**RM**
Tricorythodes	51	1	1
ISOPODA			
Caecidotea	3	2	5
LEPIDOPTERA			
Petrophila	1		
LIMNOPHILA			
Ancylidae			1
Menetus			4
Physella	1		
LUMBRICINA			
Lumbricina	1	-99	
LUMBRICULIDA			
Lumbriculidae			1
MEGALOPTERA			
Corydalus	8		
Sialis	-99		1
ODONATA			
Argia	7		6
Basiaeschna janata			-99
Boyeria			-99
Dromogomphus			1
Enallagma			5
Gomphidae	2	3	1
Hagenius brevistylus	-99		
Ischnura			1
Macromia		-99	2
Stylogomphus albistylus	1		1
PLECOPTERA			
Acroneuria	-99		
Capniidae	1		
Perlesta	1		
RHYNCHOBDELLIDA			
Glossiphoniidae			-99
TRICHOPTERA			
Cheumatopsyche	12		
Chimarra	1		

Old Mines Cr [110967], Station #1, Sample Date: 9/22/2011 12:30:00 PM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
Helicopsyche	4		
Nectopsyche	2		
Oecetis	1	2	4
Phryganeidae			2
Triaenodes			4
TRICLADIDA			
Planariidae			1
TUBIFICIDA			
Branchiura sowerbyi			2
Tubificidae	3	7	12
VENEROIDA			
Pisidiidae		2	15

Aquid Invertebrate Database Bench Sheet Report
Old Mines Cr [110968], Station #2, Sample Date: 9/22/2011 2:15:00 PM
CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
"HYDRACARINA"			
Acarina	11	5	4
AMPHIPODA			
Gammarus	-99		5
Stygobromus		3	
BRANCHIOBDELLIDA			
Branchiobdellida			2
COLEOPTERA			
Dubiraphia		47	38
Ectopria nervosa	1	1	
Helichus basalis			2
Hydrobius			1
Macronychus glabratus			1
Microcylloepus pusillus	2		24
Optioservus sandersoni	27	3	3
Psephenus herricki	24	13	2
Scirtidae			1
Stenelmis	20	3	10
DECAPODA			
Orconectes medius	-99	-99	1
Orconectes punctimanus		-99	-99
DIPTERA			
Ablabesmyia		8	2
Chironomidae	2	3	1
Corynoneura	3	3	1
Cricotopus/Orthocladius	4	2	1
Dicrotendipes		1	
Hemerodromia	5	2	8
Labrundinia	2	2	3
Microtendipes		3	2
Natarsia		2	
Nilotanypus	1		
Parakiefferiella			1
Parametriocnemus	6		3

Aquid Invertebrate Database Bench Sheet Report
Old Mines Cr [110968], Station #2, Sample Date: 9/22/2011 2:15:00 PM
CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
Paraphaenocladius		1	
Paratanytarsus			1
Phaenopsectra		1	
Polypedilum aviceps	7	2	2
Polypedilum convictum	3		1
Polypedilum illinoense grp			16
Rheocricotopus	3		6
Rheotanytarsus	5		5
Simulium	3		5
Stempellinella	55	39	29
Stictochironomus			1
Tanytarsus	56	34	51
Thienemanniella	3	1	1
Thienemannimyia grp.	11	4	6
Tipula			2
Tribelos		1	
Tvetenia			1
Zavrelimyia			2
EPHEMEROPTERA			
Acentrella	1		
Baetidae	9		3
Baetis	65		5
Caenis anceps	5	1	
Caenis latipennis	10	128	44
Eurylophella	12	4	24
Heptageniidae	17	3	
Isonychia bicolor	13		4
Leptophlebiidae	6	22	22
Maccaffertium mediopunctatum	-99		
Maccaffertium pulchellum	22		
Stenacron	10	2	
Stenonema femoratum		3	
HEMIPTERA			
Rhagovelia			1
ISOPODA			

Aquid Invertebrate Database Bench Sheet Report

Old Mines Cr [110968], Station #2, Sample Date: 9/22/2011 2:15:00 PM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
Caecidotea	6	3	48
LEPIDOPTERA			
Petrophila			2
LIMNOPHILA			
Ancylidae			2
LUMBRICINA			
Lumbricina	1	2	
MEGALOPTERA			
Corydalus	1		
Nigronia serricornis	2	-99	
Sialis		-99	
MESOGASTROPODA			
Elimia	29	-99	27
Hydrobiidae	7	2	1
ODONATA			
Argia	2	1	11
Basiaeschna janata			-99
Boyeria			1
Calopterygidae			16
Calopteryx		2	15
Gomphidae	7	4	1
Gomphus			-99
Hagenius brevistylus	1	5	3
Hetaerina			4
Stylogomphus albistylus	1	-99	2
PLECOPTERA			
Acroneuria	-99		
Capniidae	13	2	
Zealeuctra	2	-99	
TRICHOPTERA			
Cheumatopsyche	48	1	3
Chimarra	21		10
Helicopsyche	18		
Hydropsyche			3
Hydropsychidae	16		22

Aquid Invertebrate Database Bench Sheet Report
Old Mines Cr [110968], Station #2, Sample Date: 9/22/2011 2:15:00 PM
CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	**CS**	**NF**	**RM**
Mystacides		1	
Oecetis			2
Polycentropus	1		2
Triaenodes			23
TRICLADIDA			
Planariidae	5	1	4
TUBIFICIDA			
Aulodrilus	1		
Tubificidae		2	
VENEROIDA			
Pisidiidae	3		4

Aquid Invertebrate Database Bench Sheet Report
Old Mines Cr [120050], Station #1, Sample Date: 3/22/2012 12:15:00 PM
CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
"HYDRACARINA"			
Acarina	40	2	3
AMPHIPODA			
Crangonyx		4	
Hyalella azteca			9
COLEOPTERA			
Berosus		5	
Dubiraphia	14	22	19
Dytiscidae		2	
Ectopria nervosa		9	1
Helichus lithophilus			1
Lutrochus	2		
Microcylloepus pusillus	2	1	5
Optioservus sandersoni	5		
Peltodytes		1	1
Psephenus herricki		1	
Stenelmis	10		7
DECAPODA			
Orconectes punctimanus		-99	
DIPTERA			
Ablabesmyia		24	3
Antocha	1		1
Ceratopogoninae	3	3	3
Chironomidae	4		
Chironomus		2	
Chrysops		1	
Cladotanytarsus	6	1	2
Clinocera	1		
Clinotanypus		11	1
Cricotopus bicinctus	1		5
Cricotopus trifascia	2		
Cricotopus/Orthocladius	31	2	27
Cryptochironomus	3	6	
Dicrotendipes	11	5	6

Aquid Invertebrate Database Bench Sheet Report
Old Mines Cr [120050], Station #1, Sample Date: 3/22/2012 12:15:00 PM
CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
Diptera		1	
Eukiefferiella	1		
Forcipomyiinae		1	
Guttipelopia		1	
Hemerodromia	30	1	2
Labrundinia		4	1
Larsia		7	
Microtendipes	11		
Nilotanypus	1		
Nilothauma	3		
Orthocladius (Euorthocladius)	2		
Paraphaenocladius		1	
Paratanytarsus			5
Paratendipes	1	9	
Phaenopsectra	4	41	7
Polypedilum convictum	2		
Polypedilum halterale grp		1	
Polypedilum illinoense grp		1	
Polypedilum scalaenum grp	19	2	2
Pseudochironomus	4	2	
Rheocricotopus	3		2
Rheotanytarsus	27		18
Stempellinella	41	12	16
Stictochironomus	1		
Tanytarsus	93	25	61
Thienemanniella	2		3
Thienemannimyia grp.	52	4	10
Tipula	-99		-99
Tribelos	17	1	
Tvetenia discoloripes grp	2		
Zavrelimyia		1	
EPHEMEROPTERA			
Anthopotamus	1		
Caenis anceps	5		
Caenis latipennis	130	27	55

Aquid Invertebrate Database Bench Sheet Report
Old Mines Cr [120050], Station #1, Sample Date: 3/22/2012 12:15:00 PM
CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
Eurylophella	1		6
Hexagenia limbata	-99		
Leptophlebia		2	
Maccaffertium mediopunctatum	10		
Maccaffertium pulchellum	11		
Stenacron	5		
Stenonema femoratum	2		-99
Tricorythodes	35		4
ISOPODA			
Caecidotea	4	5	27
LEPIDOPTERA			
Petrophila		1	
LIMNOPHILA			
Ancylidae		3	
Helisoma		4	-99
Lymnaeidae		1	
Menetus		2	
Physella		2	1
MEGALOPTERA			
Corydalus	-99		
Nigronia serricornis	-99		
Sialis		1	
MESOGASTROPODA			
Elimia			1
ODONATA			
Argia	2		7
Boyeria			1
Calopteryx		1	-99
Enallagma			13
Hagenius brevistylus	1		-99
Hetaerina			1
Macromia			-99
Stylogomphus albistylus	-99		-99
PLECOPTERA			
Leuctridae	2	1	

Aquid Invertebrate Database Bench Sheet Report
Old Mines Cr [120050], Station #1, Sample Date: 3/22/2012 12:15:00 PM
CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
Perlesta	2		
Pteronarcys pictetii	-99		
TRICHOPTERA			
Cheumatopsyche	6		
Helicopsyche	3		
Hydroptila			2
Mystacides			2
Nectopsyche			1
Oecetis	1		8
Pycnopsyche			1
Rhyacophila	-99		
Triaenodes			5
TRICLADIDA			
Planariidae	1	3	4
TUBIFICIDA			
Branchiura sowerbyi		1	
Limnodrilus hoffmeisteri	1	3	
Tubificidae		19	
VENEROIDA			
Pisidiidae		1	3

Aquid Invertebrate Database Bench Sheet Report
Old Mines Cr [120051], Station #2, Sample Date: 3/22/2012 1:10:00 PM
CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
"HYDRACARINA"			
Acarina		5	11
AMPHIPODA			
Crangonyx	-99	1	6
Stygobromus		2	
BRANCHIOBDELLIDA			
Branchiobdellida	3		1
COLEOPTERA			
Dubiraphia		11	66
Dytiscidae		2	
Ectopria nervosa	1	1	
Helichus basalis			1
Microcylloepus pusillus	5		2
Optioservus sandersoni	17	4	1
Psephenus herricki	20	1	2
Stenelmis	37	7	7
DECAPODA			
Orconectes medius	2		
Orconectes punctimanus			-99
DIPTERA			
Ablabesmyia		11	1
Antocha	7		
Brillia	1		
Ceratopogoninae		2	1
Chironomidae	1	2	3
Cladotanytarsus		3	
Clinocera	5		
Clinotanypus		1	
Corynoneura	1	4	1
Cricotopus bicinctus	1		1
Cricotopus/Orthocladius	19	13	17
Cryptochironomus		2	2
Dicrotendipes	1	27	2
Diptera		1	

Aquid Invertebrate Database Bench Sheet Report
Old Mines Cr [120051], Station #2, Sample Date: 3/22/2012 1:10:00 PM
CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
Eukiefferiella	4		
Eukiefferiella devonica grp	21		1
Hemerodromia	12	2	3
Labrundinia			6
Micropsectra	2	1	2
Microtendipes		2	1
Natarsia			1
Nilotanypus	1		
Odontomyia	1		
Parakiefferiella		10	1
Paratanytarsus	1	2	10
Paratendipes		14	2
Phaenopsectra		5	
Polypedilum aviceps	35		5
Polypedilum fallax grp	1		1
Polypedilum illinoense grp	1	3	9
Rheocricotopus	7	2	4
Rheotanytarsus	26	2	7
Simulium	10		1
Stempellinella		64	36
Tabanus	1		
Tanytarsus	25	88	62
Thienemanniella		1	1
Thienemannimyia grp.	13	15	7
Tipula	1		
Tribelos			1
Tvetenia bavarica grp	7		1
Zavrelimyia		3	
EPHEMEROPTERA			
Acentrella	32		
Baetis			1
Caenis latipennis	16	67	40
Diphetor	5		
Eurylophella	1	7	16
Isonychia bicolor	20		

Aquid Invertebrate Database Bench Sheet Report
Old Mines Cr [120051], Station #2, Sample Date: 3/22/2012 1:10:00 PM
CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
Leptophlebiidae	2		-99
Maccaffertium mediopunctatum	1		
Maccaffertium pulchellum	123		
Stenacron	3	5	1
Stenonema femoratum	1		
ISOPODA			
Caecidotea	5	13	19
Caecidotea (Blind & Unpigmented)		1	
LIMNOPHILA			
Ancylidae		1	
LUMBRICINA			
Lumbricina	-99	1	-99
LUMBRICULIDA			
Lumbriculidae		1	
MEGALOPTERA			
Corydalus	1		
Nigronia serricornis	6		-99
MESOGASTROPODA			
Elimia	9		4
ODONATA			
Argia			1
Basiaeschna janata			-99
Calopteryx			2
Gomphidae	2		-99
Hagenius brevistylus		2	3
Stylogomphus albistylus		-99	3
PLECOPTERA			
Acroneuria	3		
Amphinemura	3		
Isoperla	1		
Leuctridae	8	17	10
Perlesta			1
TRICHOPTERA			
Cheumatopsyche	63		2

Aquid Invertebrate Database Bench Sheet Report
Old Mines Cr [120051], Station #2, Sample Date: 3/22/2012 1:10:00 PM
CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
Chimarra	33		
Helicopsyche	6		5
Hydropsyche	22		
Micrasema	5		
Oecetis			3
Polycentropus	1		2
Pycnopsyche		-99	3
Rhyacophila	38		1
Triaenodes			8
TRICLADIDA			
Planariidae	5		1
TUBIFICIDA			
Limnodrilus hoffmeisteri		1	1
Tubificidae			1
VENEROIDA			
Pisidiidae		1	13